# SPECIFICATIONS

FOR

## TWO HORIZONTAL DIRECT-ACTING

# COMPOUND SCREW-ENGINES

FOR A

## TWIN-SCREW VESSEL

OF

## 1,700 TONS DISPLACEMENT,

EACH ENGINE, WITH ITS AUXILIARIES, OF 1,650 I. H. P.

UNDER FORCED DRAUGHT;

INCLUDING

BOILERS, SCREW-PROPELLERS, AND ALL APPENDAGES AND APPURTENANCES COMPLETE, TOGETHER WITH A LIST OF TOOLS, INSTRUMENTS, AND DUPLICATE PIECES TO BE FURNISHED.



WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1886.

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# SPECIFICATIONS

FOR

TWO HORIZONTAL DIRECT-ACTING

# COMPOUND SCREW-ENGINES

AND

# BOILERS

FOR A

## TWIN-SCREW VESSEL OF 1,700 TONS DISPLACEMENT.

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REFERENCE BEING HAD TO THE ACCOMPANYING DRAWINGS, WHICH ARE TO FORM A PART OF THESE SPECIFICATIONS.

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## GENERAL DESCRIPTION.

### CYLINDERS AND JACKETS.

The engines are to have, each, a high and low-pressure cylinder of 29 and 52 inches diameter respectively; a piston stroke of 30 inches, and the number of revolutions to be about 150 per minute when developing 1,650 horse-power.

The engines will be placed in separate water-tight compartments, and will be duplicates, the low-pressure being forward of the high-pressure cylinder in the forward, and abaft it in the after compartment; the forward engine turning the starboard propeller.

The cylinders, together with their covers and ends, will be jacketed.



### RECEIVER AND STOP-VALVE.

The receiver of each engine will consist of the passages and pipes connecting the high-pressure and low-pressure valve-chests, and will be fitted with a safety-valve, and a valve for admitting steam direct from the main steam-pipe.

The seat of the engine stop-valve, which will be used as a throttle, will be carried in the casing of each high-pressure cylinder. The stem will lead to the working platform, and be fitted with a suitable hand-wheel.

### MAIN VALVES—VALVE-GEAR.

The main steam-valves are to be of the piston type; there will be one for the high-pressure and two for the low-pressure cylinders.

The valves will be worked by radial valve-gear, as shown in the drawings, and arranged to cut off steam between the limits of 0.25 and 0.66 of the stroke in the high-pressure, and between 0.50 and 0.66 in the low-pressure cylinders.

### PISTON-RODS—CROSS-HEADS.

Each piston is to have one piston-rod secured to a cross-head, which will run in self-lubricating guides, bolted to its cylinder at one end and supported by a column at the other.

### CRANK-SHAFT.

Each crank-shaft will be a solid forging, made of steel, in two interchangeable sections, and with the necessary coupling-discs forged on. The two sections will be bolted together, with their cranks at right angles; and united to the line shafting by a flexible coupling. Counter-balances will be fitted to crank-throws for use if required.



### AIR-PUMPS.

The air-pumps, one for each engine, will be inclined and double-acting. Each will deliver into a feed-tank in engine-room, and be worked from a crank bolted to forward end of crank-shaft.

### CIRCULATING—PUMPS.

There will be a centrifugal circulating-pump in each engine-room driven direct by its engine, and arranged to permit of its being used for freeing the ship from water in case of necessity.

### CRANK-SHAFT PILLOW-BLOCKS.

The castings containing the crank-shaft bearings will be cast in one piece for each engine. They will be bolted to engine keelsons; and stayed to cylinders by steel tie-rods.

### HOT—WELL OR FEED—TANK.

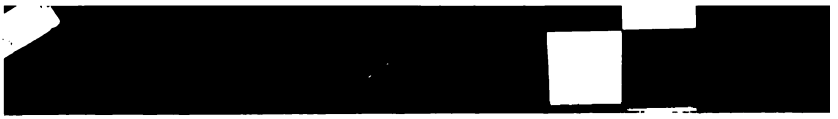
The air-pump of each engine will discharge into a feed-tank of boiler-iron placed directly over the air-pump delivery-valves. Each tank will have a capacity of 150 gallons, and will be partitioned to act as a filter.

### CONDENSERS.

The shells of condensers will be cylindrical and made of brass. They will be fitted with brass tubes, $\frac{5}{8}$ inch diameter outside; and will have, each, a cooling surface of about 2,930 square feet measured on the outside of the tubes. The condensers will be supported on stanchions, and otherwise well secured in the ship.

The tubes will be placed fore-and-aft, the water circulating through one-half of them and returning through the other half, thence overboard through outboard delivery-valves.

Suitable baffling and supporting plates will be arranged in each condenser to assist in the circulation of steam and to support the tubes.





MAIN FEED-PUMPS.

There are to be two vertical duplex pumps fitted in each fire-room of ample capacity for feeding the boilers. One set in each fire-room will be fitted to draw from feed-water tank and bottom of forward condenser and discharge through boiler check-valves.

AUXILIARY FEED-PUMPS.

The second set in each fire-room will be fitted to draw water from tank, sea, bilge, and boilers, and to discharge into fire-main, through boiler-checks and overboard. The pump in forward fire-room to likewise discharge through distiller.

BILGE AND FIRE-PUMPS.

A horizontal pump of 200 gallons capacity per minute is to be placed in each engine-room, and fitted to draw water from the sea and bilge, and to discharge into fire-main and through outboard-delivery.

The water-cylinders and chests of all pumps are to be of composition.

EVAPORATOR, DISTILLER, AND PUMP.

The distilling apparatus will be located where directed, and will consist of one or more evaporators and distillers capable of furnishing 2,000 gallons of potable water in twenty-four hours. The circulating water for the distiller will be supplied by the auxiliary pump in forward fire-room. There will be a steam-pump conveniently located for feeding the evaporators. It will have a capacity equal to a No. 0 Blake pressure-pump, and will draw water from the sea, and deliver through check-valves on the evaporators.

PROPELLERS.

The propellers are to be three-bladed, right and left handed, respectively, of about ($11\frac{5}{10}$) feet diameter, and will be made of manganese bronze.



BOILERS.

There will be four cylindrical horizontal tubular boilers, containing an aggregate grate-surface of 240 square feet, arranged fore-and-aft, in two water-tight compartments, each with a fire-room athwart-ship abaft the after boilers and forward of the forward boilers; the width of fire-rooms to be 8 feet 6 inches. Each boiler will be 10 feet in diameter and 16 feet long.

The smoke-pipe will be fixed, and its top will be about 55 feet above the grates.

BLOWERS.

Both fire-rooms are to be arranged to work under air-pressure when required, and to be fitted, each, with two blowers capable of supplying 12,000 cubic feet of air each per minute under a pressure of 4 inches of water.

## DETAILED DESCRIPTION OF ENGINES, SHAFTING, PROPELLERS, BOILERS, PUMPS, &c.

CYLINDER-CASINGS.

The-cylinder casings, which will include the steam and exhaust ports and passages, inboard heads, valve-chests, and sole-plates, are to be of cast-iron. The casing for the high-pressure cylinder will be 34½ inches diameter inside, and 1⅛ inches thick; that for the low-pressure cylinder will be 54½ inches diameter, and 1⅛ inches thick.

They will be fitted with cylinder linings of hard cast-iron; and an annular space of 1½ inches will be left for jacket between casing and lining.

RECEIVERS.

The receivers will consist of the spaces between high-pressure and low-pressure piston-valves and their connecting pipes. There will be two copper pipes, of 12 inches internal diameter



each, connecting each high-pressure exhaust-nozzle with the steam-chest of low-pressure cylinder. Each pipe will be fitted with a butterfly governor-valve and an expansion-joint, as shown in drawings; will have faced composition flanges not less than 3 inches wide, and will be secured in place by wrought-iron bolts and nuts.

Through bolts are to be used where practicable.

There will be a 3-inch copper pipe, with composition stop-valve, connecting main steam-pipe to receiver space; and a composition safety-valve, with nickel seat of 2 inches diameter on the receiver, weighted to 40 pounds per square inch above the atmosphere.

The cylinder casings and covers, after being placed in the ship, are to be covered with non-conducting material, and neatly lagged with black walnut, removable where directed.

### SOLE-PLATES.

The cylinder casings will rest upon legs, with sole-plates well ribbed, cast on them of the same length as the casings, faced $1\frac{1}{2}$ inches thick. The distance from axis of cylinders to faces of sole-plates to be 33 inches. The horizontal distance between the axis of high-pressure and low-pressure cylinders to be 62 inches.

### CYLINDER LININGS.

The linings are to be of cast-iron as hard as tools can work. They will be $1\frac{1}{4}$ inches thick, and made with faces and flanges accurately fitted in and secured to the casings, as shown in the drawings. They are to be smoothly and accurately bored to a diameter of 29 inches for the high-pressure, and 52 inches for the low-pressure cylinder, and are to be of suitable length for a piston-stroke of 30 inches.

The jacket-space will be $25\frac{1}{2}$ inches long, and there will be a packing space at the outboard ends $1\frac{1}{2}$ inches by 3 inches. The linings will be secured in place by bolts passing through



the cylinder-heads, with nuts on the outside, the joint at inboard end of each cylinder being made tight by a copper grommet under the flange. A copper wire or grommet with follower and bolts will likewise be used for packing the expansion-joint at the outboard ends of cylinder linings.

### CYLINDER-HEADS AND COVERS.

The cylinder-heads are to be made with double-shells, $\frac{7}{8}$ of an inch thick, amply stiffened by ribs of same thickness. They will have suitable openings for the stuffing-boxes and man-hole plates, which are to be properly fitted. The cylinder-covers are to be made of the best cast-iron, with double shells well-ribbed, of the same thickness as the cylinder-heads. Each low-pressure cover will have a man-hole cast in, which will be bored and faced to receive the man-hole plate. The cylinder covers are to be faced true on the inside, rough-finished on the outside and lagged. They are to have faced flanges $3\frac{1}{2}$ inches wide, $1\frac{5}{8}$ inches thick, and are to be secured to cylinder casings by wrought-iron bolts $1\frac{1}{4}$ inches diameter, with finished nuts. Bolts are to be spaced not over 6 inches apart.

### HOLDING-DOWN BOLTS.

All holding-down bolts for securing the engines in the ship are to be fitted with lock-nuts.

### MAN-HOLES AND PLATES.

The man-holes in low-pressure cylinder covers and in the heads of low-pressure cylinders are to be 15 inches in diameter. The plates are to be cast with double shells, turned to loosely fit the holes, faced on the inner surface to fit the facing-strip on cover or head, and to be finished on the outside. They are to have flanges 3 inches wide, and $1\frac{1}{4}$ inches thick, and are to be secured by wrought-iron bolts $1\frac{1}{8}$ inches diameter, spaced not over 6 inches apart, and with finished wrought-iron nuts.



### VALVE-CHESTS AND COVERS.

The high-pressure and low-pressure valve-chests will have openings at each end for inserting and removing the valves, and will be closed by single plate covers of cast-iron, well ribbed, finished on outside with faced flanges 3 inches wide and 1¼ inches thick.

The inboard covers will contain the valve-stem stuffing-boxes, the bushes and glands being of composition. The packing-spaces will be ¾ inch wide, and 5½ inches deep, and fitted for metallic or ordinary packing. Both inboard and outboard covers will have projecting from their inner surfaces suitable guides bushed with brass, for sustaining the weight of the valves. The covers will be secured in place by 1¼-inch bolts, spaced not over 6 inches apart, and with finished wrought-iron nuts. Suitable bosses will be cast on the upper surface of steam-chests, directly over each steam-port, for the attachment of approved oil-cups.

### VALVE-SEATS.

The valve-seats are to be made of cast-steel of the toughest quality combined with a suitable degree of hardness. They are to be 1½ and 1¼ inches thick, and are to be secured as shown in drawings and accurately bored in place to a diameter of 14 inches for the high and 18 inches for the low-pressure cylinders.

### STEAM-PORTS.

The high-pressure cylinder steam-ports will be 2 inches and the low-pressure 2¾ inches wide. There will be 8 diagonal, alternating right and left, bridges in the high-pressure, and 12 in each low-pressure valve seat. All bridges are to be ¾ of an inch wide.



### MAIN STEAM PISTON-VALVES.

The piston-valves of the high-pressure cylinders will be made of cast-iron, the thickness of metal in the body of the valves being $\frac{1}{2}$ inch, and the central connecting trunks having an internal diameter of not less than 13 inches.

The low-pressure piston-valves will be made of composition $\frac{3}{8}$ inch thick in the body of the valve, and the connecting trunks will have an internal diameter of not less than $16\frac{1}{2}$ inches.

The valves of both high-pressure and low-pressure cylinders will have cast at either end a central boss with radial arms for attachment of the valves to their stems.

Each end of all valves will be made steam-tight by two packing-rings of cast-iron, $1\frac{1}{2}$ x 1 inch in cross-section, cut obliquely and tongued, and held in place by a composition follower and wrought-iron bolts. The distance pieces for separating the packing-rings at each end of the valves will be made of cast-iron for the high-pressure and of composition for the low-pressure valves.

### MAIN VALVE-STEMS.

The valve-stems will be made of cast-steel, $1\frac{3}{4}$ inches diameter where they pass through the valves, and 3 inches diameter in the stuffing-boxes. The thread on each stem where it is secured to the valve will be raised above the body of the rod, and the stem will be secured in place by a nut on each side of the cross-bar, the inner nut being of steel, and the outer one formed by a cast-iron sleeve 3 inches external diameter, which will be locked in place by a steel nut secured by a pin. This sleeve will travel in a composition bushing fitted in the inner projection of its outboard cover, and will be furnished with an approved lubricating device.

Each valve-stem, where it passes through its cross-head, will be reduced to a diameter of $2\frac{1}{2}$ inches, and be secured by a steel nut on each side, with suitable locking device.



### MAIN VALVE-STEM CROSS-HEADS.

The valve-stem cross-heads will be made of steel. Each will be bored to receive its valve-stem and counterbored for the recessed valve-stem nuts.

The connections of cross-heads to valve motion rock-shafts will be made by two links with conical ring bearings, as shown in the drawings.

### THROTTLE AND STOP-VALVES.

The main steam-throttle for each high-pressure cylinder will consist of a disc-valve 10 inches diameter of opening, closing against the pressure in the steam-pipe. The seat will be carried in the cylinder casing, and the opening through the outside of casing will be closed by a finished cast-iron cover carrying the stuffing-box and gland.

The stem will project horizontally and be fitted with a finished wrought-iron wheel, arranged as shown in the drawing.

The valve-stem will be prevented from turning by a gib in the guide under the valve, which will fit a groove in the valve stem.

### VALVE-GEAR.

The valve-gear is to be of the radial type, and is to be so designed and constructed as to cut off steam between the limits of 0. 25 and 0. 66 of the stroke of the high-pressure pistons, and 0. 50 and 0. 66 of the stroke of the low-pressure pistons.

The cut-offs of the high-pressure and low-pressure cylinders are to be capable of being adjusted from the working platform, independently of each other.

The various functions of the valves must fall within the following limits, the fraction of the stroke being in all cases estimated from the beginning of the stroke:



HIGH-PRESSURE VALVE LIMITS.

| | Not earlier than— | Not later than— |
|---|---|---|
| | Stroke. | Stroke. |
| Minimum cut-off | 0.23 | 0.27 |
| Maximum cut-off | 0.64 | 0.70 |
| Exhaust opening at minimum cut-off | 0.76 | 0.81 |
| Exhaust opening at maximum cut-off | 0.91 | 0.93 |
| Exhaust closing at minimum cut-off | 0.60 | 0.66 |
| Exhaust closing at maximum cut-off | 0.84 | 0.87 |

LOW-PRESSURE VALVE LIMITS.

| | Not earlier than— | Not later than— |
|---|---|---|
| | Stroke. | Stroke. |
| Minimum cut-off | 0.48 | 0.52 |
| Maximum cut-off | 0.64 | 0.70 |
| Exhaust opening at minimum cut-off | 0.91 | 0.93 |
| Exhaust opening at maximum cut-off | 0.93 | 0.95 |
| Exhaust closing at minimum cut-off | 0.68 | 0.72 |
| Exhaust closing at maximum cut-off | 0.80 | 0.82 |

The angular positions of the crank-arms when steam is admitted must be the same in all gears of forward motion, and must not be farther than 10° from the dead center, nor nearer than 7°.

The width of the port-opening for steam admission must be at least 2 inches at maximum cut-off, and $\frac{7}{16}$ inch at minimum cut-off for the high-pressure engines, and $2\frac{1}{2}$ inches and $1\frac{1}{2}$ inches respectively, for the low-pressure engines.



The distribution of steam in backward-gear must be such as to permit the engines to be reversed quickly and to run astern at full power.

The eccentrics are to be forged from scrap-iron or from mild steel. Each eccentric is to be made in two parts, securely fastened together by two mild-steel bolts. They are to be truly bored to fit the shaft, and to be secured to the same by steel feather-keys and set-screws of approved dimensions. They are to be truly turned to a suitable eccentricity, and recessed at the sides to fit the flanges of the eccentric straps. Each eccentric is to be keyed upon the shaft with its line of eccentricity 8° in advance of the adjoining crank.

Each eccentric strap is to be in two parts, of cast-steel, with brass bushings securely fitted and truly turned to fit the eccentrics. The two parts are to be firmly fastened together by two mild-steel bolts with lock nuts and keepers. The two parts of the strap are to be separated by suitable brass chipping pieces. A prolongation of one part of each eccentric-strap will form the eccentric-lever.

Each eccentric-lever will carry two mild-steel pins, each with a hardened steel thimble securely fastened.

One of these pins to engage with the radius-link and the other with the valve connecting-rod.

The movement of each valve is to be regulated by a reversing-arm and a radius-link.

Each reversing-arm is to be carried in bearings rising from the top of the corresponding crank-shaft bearing with its main centre line parallel to the axis of the crank-shaft, and in the same vertical plane. The reversing-arm with its journals to be of cast-steel. A forged-steel pin is to be secured in the free end of the arm to engage with the radius-link. Each radius-link is to engage at one end with this pin and at the other with the lower pin on the eccentric-lever. A part of the reversing-arm is to form a toothed-sector meshing with a worm on the reversing-shaft.



Each valve connecting-rod will engage at one end with the corresponding pin in the eccentric-lever and at the other end with a pin in an arm on the valve-motion rock-shaft. The valve connecting-rods are to have such ends that the lengths between centres may be adjusted as desired.

The valve-motion rock-shafts are to be carried in bearings bolted to the cylinder-casings, and are to have arms set at suitable inclinations to each other by which the motion will be transmitted to the valve-stems by links.

The radius-links, valve connecting-rods, valve-motion rock-shafts, valve-motion rock-shaft arms, valve-motion cross-heads, and valve-links are to be forged of mild steel, finished all over.

All joint-pins are to be of steel, hardened and ground to true circular cylindrical surfaces.

All working-bearings are to be of phosphor bronze.

The housings of the reversing-arm bearings, and the reversing-arms are to be of cast-steel.

The radius-links are to be capable of adjustment so as to preserve a constant distance between centers when taking up lost motion.

Fixed trammels are to be furnished, suitably protected from injury, for setting the radius-link centers to their proper distances.

The valve-stems are to be marked and furnished with fixed trammels for setting the valves without removing the valve-chest bonnets.

A spare set of phosphor-bronze bearings is to be furnished for all adjustable joints.

All parts of the valve-gear are to be suitably marked for convenience of putting together properly when overhauling.

The valve-gear is to conform to such drawings as shall be furnished.

### REVERSING-GEAR.

Each engine will have an independent reversing-gear, each of which will consist of a double-upright inverted-cylinder engine, driving by bevel toothed-gearing the worm-shaft which engages with the sector on the reversing-arm.



Each reversing-engine is to be properly bolted to lugs forged on the framing tie-rod of the corresponding main engines. These lugs are to be supported by stanchions bolted to them and to the engine keelsons. These engines are to have cylinders of 5 inches bore and 4 inches stroke of piston. The cylinders and valve-chests are to be in one casting, of composition. The pistons and piston-valves are to be of composition, with approved packing.

The cylinders are to be carried on mild-steel stanchions, stepped in the engine bed-plate. These stanchions are also to carry the cross-head slides, the valve rock-shafts, the shaft carrying the wheel which operates the differential valve-gear, and the rock-shaft connected with the hand-reversing lever. The engines are to have piston-valves without lap or lead.

Each piston-valve is to be worked, through a suitable rock-shaft and levers, by the cross-head of the adjoining engine.

The reversing of each reversing-engine is to be effected by a piston-valve so constructed as to change the ports of the engine-valves from steam to exhaust, and vice-versa.

The reversing-valves are to be worked by a differential screw-motion, so constructed that the reversing-engines shall follow the motion of the reversing-lever.

Each pair of main engines is to have one reversing-lever, which is to be conveniently placed to be worked from the working-platform, and to be fitted with a spring-catch engaging in notches in a fixed sector.

The notches are to be plainly marked for the ahead and astern motions and for the various grades of expansion.

The reversing-lever sectors are to have adjustable-stops to prevent the levers being thrown beyond the full ahead and astern positions.

The reversing-levers are to be connected by the necessary rods and bell-cranks to the differential screw-motion of the reversing-valves.

Each reversing-engine is to have a cylindrical throttle-valve so constructed that when steam is shut off the engine,



the valve-chests shall be in communication with the atmosphere.

Each of these throttle-valves is to be worked by an independent lever from the working-platform.

The levers are to have spring-catches to hold them in the full open and shut positions.

There will also be a stop-valve in the pipe taking steam to both reversing-engines, with such gear that the valve may be worked from the working-platform while handling the reversing-lever.

The reversing-engines are to exhaust into the feed-tank. The exhaust-pipes are to have no valves or cocks in them which can prevent a free exhaust.

Each reversing-worm shaft is to be carried in two bearings. The lower bearing, which is to be carried by the tie-rod of the main engine-frame, is to be suitably arranged to take the thrust of the worm-shaft. The upper bearing is to rise from the housing of the reversing-arm bearings.

The thrust-collars on the worm-shaft are to be capable of adjustment for lost motion.

The reversing-engine crank-shafts, stanchions, pillow-block caps, all bolts, the cross-head slides, and the worm-shafts are to be of mild-steel. The piston-rods, valve-stems, valve connecting-links, connecting-rods, cross-heads, and all bearings, are to be of phosphor bronze. The cylinders and valve-chests are to be neatly cast and left unlagged. All toothed gearing is to be cut from solid blanks.

A shield of sheet-brass of about No. 16 B. W. G. is to protect the back and ends of each reversing-engine from water spattered by the cranks.

Each reversing-worm shaft is to be squared on top and a suitable box-wrench provided for reversing by hand.

Suitable stops with approved elastic-buffers are to be provided to prevent the reversing-arm being thrown over so far as to endanger any part of the mechanism.



### STEAM-GOVERNOR.

There will be an efficient governor of an approved type, with all necessary connections fitted to the governor-valves of each set of engines for preventing racing in rough weather.

### CYLINDER RELIEF-VALVES.

There will be an automatic relief-valve, of not less than 4½ inches diameter, located near the bottom at each end of each cylinder. These valves will be kept on their seats by spiral springs with approved method of adjustment. These springs to be long enough to allow the valves to open to their full extent without unduly increasing the load. The valves to be guided by loosely fitting wings. The springs are to bear on shoulders on spindles which fit loosely in sockets recessed in the backs of the valves. These spindles to be so fitted that the valves can be moved by the application of a lever. The valves to be fitted with casings which will prevent danger of people being scalded by hot water from the cylinders, and prevent steam and water reaching the valve-springs. Suitable fulcrums to be on casings, for the application of levers for working the valves. One lever to be furnished for each engine. A spare spring for each valve to be furnished. All springs to pass a satisfactory test.

### CYLINDER DRAIN-COCKS.

There will be fitted to each end of each cylinder, as low as possible, a drain-cock of approved design with 1¼ inch opening. These cocks to have bottoms cast in their shells and to have stuffing boxes at large end. The shells to have set screws with conical points bearing against the bottoms of the cocks to prevent setting fast. These cocks to be made of composition and to be *flanged* and bolted to bosses on cylinder casings or heads. The cocks on each cylinder to be operated by one lever at working-platform. A pipe leading to bilge is to be attached to each cock by a union-joint with conical bearing.



MAIN-PISTONS.

The pistons will be made of composition, with double shell well-ribbed. The thickness of the metal to be $\frac{7}{16}$ inch, and that around the eyes of the piston-rods to be $1\frac{1}{4}$ inches. Each piston will have two cast-iron wearing-rings, $4\frac{1}{2}$ inches wide, upon which it will rest. These rings to be so fitted that any part of the circumference can be adjusted to take the wear. The packing-rings are to be $\frac{5}{8}$ of an inch thick, 2 inches wide, and will be adjusted by steel-springs of proper tension. The followers are to be $1\frac{1}{8}$ inches thick, and secured in place by six wrought-iron bolts for the high, and eight for the low-pressure pistons; all are to be $1\frac{1}{8}$ inches diameter.

All core-holes are to be in the periphery of the pistons.

PISTON-RODS.

The piston-rods are to be of steel, finished 5 inches diameter, fitted and secured to the pistons with closed countersunk composition nuts, locked in position.

The rods will be screwed into and securely locked to cross-heads.

CYLINDER TIE-RODS.

The tie-rods securing the cylinders to pillow-block frames will be made of steel, turned to a diameter of $4\frac{1}{2}$ inches. They will have T-heads forged on each end, and the forward and after tie-rods of each engine will have lugs forged on them for the attachment of the reversing-engines and worm shaft thrust. These rods will be secured to the pillow-blocks, by the crank-shaft bearing cap-bolts, and to the cylinders, by steel-bolts of the same size as the cap-bolts, tapped into nuts pocketed in the cylinder-casings.

PISTON-ROD STUFFING-BOXES.

The piston-rod stuffing-boxes will be formed in the cylinder-heads, and will be fitted with composition bushings and glands,



The packing-space will be 1 inch wide and 8 inches deep, and will be fitted for an approved metallic packing.

### CROSS-HEADS.

The cross-heads are to be of steel, finished all over, and fitted with composition slippers 18 inches wide, 19 inches long, and $\frac{1}{2}$ inch thick; each secured in place by a flange and 4 wrought-iron bolts, as shown in drawings.

The brasses for connecting-rod journals are to be $1\frac{1}{2}$ inches thick, faced 10 inches long, and bored to a diameter of $5\frac{1}{2}$ inches. They will be clamped by a steel cap, secured by 2 mild steel bolts, $3\frac{1}{4}$ inches diameter, fitted with locked nuts.

### CROSS-HEAD SLIDES.

The cross-head slides will be made of hard cast-iron, with an oil-gutter at each end. They will have composition backing slides $4\frac{1}{2}$ inches wide, each secured by six 1-inch wrought-iron bolts.

The slides will be well secured to the cylinders at one end, and supported and fixed at the other end on a column, which will rest upon a keelson, and be substantially fixed to it.

### CONNECTING-RODS.

The connecting-rods are to be of the best mild steel, finished all over. They will be 60 inches long between centers, $5\frac{1}{2}$ inches diameter of neck at crank-pin end, and 5 inches diameter of neck at cross-head end. Each rod will be divided at the cross-head end, and have a pin $5\frac{1}{2}$ inches diameter and 10 inches long, worked from the solid forging, for the cross-head journal. This pin will have a hole drilled axially from end to end, $\frac{3}{4}$ inch diameter.

The caps for the crank-pin brasses will be made of steel, each secured by two mild-steel bolts, $3\frac{1}{4}$ inches diameter, fitted



with steel collar-nuts recessed into caps and secured by steel retaining-screws. The end of each bolt, where projecting through the nut, to be reduced to the diameter at bottom of threads, finished hemispherically, and fitted with a split-pin. The brasses for crank-pins are to be 1½ inches thick, and accurately fitted to pins and rods.

### CRANK-SHAFTS.

The crank-shaft for each set of engines will be made of steel, forged with solid webs and couplings, and in two interchangeable sections, each 6 feet 1 inch long, which will be bolted together with their cranks at right angles.

The shaft-journals will be 10 inches diameter, the central journals 11 inches long each, and the forward and after journals each 18 inches long. The crank-shaft webs will be 7 inches thick. The crank-pins will be 10 inches diameter and 15 inches long. The couplings will be 2¾ inches thick and 21 inches diameter. The crank-pins and shaft-journals will have 3½ inch holes drilled axially through them. The crank-pins will have radial holes extending to the surface of the pins, as shown in drawings.

All journals when finished will be tested and their accuracy proved.

A crank having a throw of 12 inches will be bolted to the flange on forward section of each shaft for working the air-pump.

### CRANK-SHAFT AND CRANK-PIN BRASSES.

These brasses will be made in two parts, the crank-shaft brasses 1¾ inches thick and the crank-pin brasses 1½ inches thick, and bored 10 inches diameter. They will be faced to allow ample end motion and to match the adjoining webs or eccentrics.

The shaft-brasses will be bored in place and will have a hole 2 inches in diameter in the center of each cap-brass through which the journal may be seen.



Both shaft and crank-pin brasses will be scraped to accurately fit their journals.

### BED-PLATES AND PILLOW-BLOCKS.

The bed-plates for pillow-blocks will each be made in one casting, from which will spring the pedestals for crank-shaft bearings. The plates and pedestals will be cast hollow, with walls $1\frac{1}{4}$ inches thick, the metal around the brasses not to be less than $2\frac{3}{4}$ inches thick. The bottom of bed-plates will be faced $1\frac{3}{4}$ inches thick and $4\frac{1}{2}$ inches wide, and will be well-ribbed to the walls of the plate. The jaws of the bearings will be closed by finished cast-steel caps with a hand-hole in each, and will conform in width to the jaws and be secured to them by two mild-steel collar-bolts, $2\frac{3}{4}$ inches diameter, which will also serve as retaining-bolts for the cylinder tie-rods. These bolts will be fitted with wrought-iron stoppered nuts, secured by steel set-screws.

### SURFACE-CONDENSERS.

The condenser-chests are to be cylindrical in form, "built up" of sheet brass $\frac{1}{4}$ inch thick, amply sustained by angle and T-rings and composition flanges for the tube-plates.

The exhaust and discharge-nozzles, also the chambers for the circulating water and the covers for the same, are to be of composition as thin and light as practicable, combined with ample strength and stiffness. The diameters of the three exhaust-openings, and of the discharge-openings to air-pumps, are to be 10 inches. The injection and delivery-openings for the circulating water will be $9\frac{1}{2}$ inches in diameter. All flanges to be not less than 3 inches wide.

An internal pipe of brass, suitably perforated for spraying the water, is to be fitted to each condenser for use as a salt-water feed, the pipe to be 3 inches diameter and to have a composition stop-valve attached, connecting it to the circulating side of the condenser.



Each chest will contain 1,791 seamless drawn brass tubes, $\frac{5}{8}$ inch outside diameter of No. 20 B. W. G. thickness, spaced $\frac{15}{16}$ of an inch between centers.

The exposed condensing length of tubes to be 10 feet, having a total cooling surface of 2,930 square feet. The tubes in each condenser will be arranged in two divisions, so that the condensing water will pass first through the tubes of one division, then through the tubes of the other to the outboard delivery-valve. The tubes are to be thoroughly tinned inside and out previous to the last drawing.

The tube-plates are to be of brass $1\frac{1}{8}$ inch thick, bored or cored for the tubes, and counter-bored $\frac{13}{16}$ inch diameter and $\frac{3}{4}$ inch deep; the packing to be compressed by composition-glands screwed into the plates, and to have a device for preventing crawling of the tubes.

The tubes will be suitably supported by an approved system of composition diaphragm and deflecting-plates in each condenser.

The condensers will be located behind the engine cylinders, to which they will be stayed, and will be supported on stanchions or saddles, and otherwise well secured in ship. Additionally the condenser in the forward compartment will be fitted with straightway-valves in its cylinder exhaust-pipes, and discharge-pipe close to air-pump, for closing all communication with the main engines when the condenser is used for auxiliary purposes. The openings of these valves to be equal to the area of their respective pipes.

The diaphragm in the circulating water-chamber of each condenser will be fitted with a rectangular hinged-valve of composition, having an opening of 12 by 12 inches for allowing the water from the circulating-pump to pass overboard directly when that pump is used for bilge purposes. This valve will be operated by a lever for closing and securing it when it is desired that water should pass through the tubes of the condenser.



### EXHAUST-PIPES.

The exhaust-pipes, three in number, connecting each low-pressure cylinder with condenser will be 10 inches internal diameter each, and made of copper. They will be fitted with expansion-joints and with composition flanges, faced 3 inches wide, riveted and brazed. The opening in bottom of condenser for the discharge of water and vapor will be connected to the induction side of air-pump by a composition pipe of 5 by 9 inches internal cross-section, with flanges faced 3 inches wide.

The auxiliary exhaust-main, where it passes through the engine-compartments, will have a diameter of 6 inches and will be made of copper. It will have in each engine-compartment two exhaust-connections; one to condenser and one to engine-room receiver, each 4 inches internal diameter. All flanges will be made of composition, faced not less than 3 inches wide, riveted and brazed.

### AIR-PUMPS.

Each engine will have an inclined double-acting air-pump, 13 inches diameter and 24 inches stroke, which will be operated by a crank bolted to forward section of crank-shaft.

The pump-cylinders, valve-chests, covers, bonnets, and valve-seats will be made of composition. The cylinders will be 1¼ inches thick and of sufficient length for a stroke of 36 inches.

The valve-chests will contain, at each end of the pump, valve-seats, properly faced, with 18 induction and 16 delivery-valves of 4 inches diameter of opening, arranged as shown in drawings. The valves are to be made of hard rubber, and will be fitted with brass guards and volute springs of proper tension. The pump-pistons will be made of composition, with efficient metallic packing. The piston-rod of each pump will be made of phosphor bronze 2½ inches in diameter, secured in the piston by a composition collar-nut



### INJECTION-VALVES.

The chests, valves, seats, bonnets, glands, screw-stems, and hand-wheels of the injection-valves are to be of composition.

Each valve will be faced with vulcanized rubber, and will cover an opening through the seat of 10 inches diameter.

Each chest will have a nozzle of 4 inches diameter of opening, under the valve, for fire-pump suction.

Composition strainers, perforated with $\frac{3}{8}$-inch holes equivalent in area to twice the area of valve, will cover the openings through the ship.

### BILGE INJECTION.

A copper pipe of 10 inches internal diameter will connect the main injection-valve chest with the bilge in each engine compartment. The pipe will have attached to it a composition non-return valve of 10 inches diameter of opening, which will be located in each compartment as shown in the drawings.

### OUTBOARD-DELIVERY VALVES.

The chests, bonnets, seats, valves, stems, and glands of outboard-delivery valves will be of composition.

The valves are to be fitted as checks, to open by pressure from inside, and faced with rubber to cover openings through seats 10 inches diameter. Each chest will have a nozzle of 4 nches diameter of opening, outside the main valve, for the bilge-discharge from auxiliary pumps.

### SEA-VALVES.

There are to be two sea-valves of not less than 5 inches diameter of openings for each fire-room, one to be used for blow and the other for sea-suction. One set will be located between frames 41 and 42, and the other set between frames 60 and 61; the center of each valve to be 24 inches from the center line



EVAPORATORS, DISTILLERS AND THEIR PUMPS.

The distilling apparatus will be located on the berth-deck where directed, and will consist of one or more evaporators and distillers of approved design capable of furnishing 2,000 gallons of potable water in 24 hours.

The auxiliary pump in fire-room will be used as a circulating-pump for the distillers. The pumps for supplying the evaporators will have a capacity equal to a No. 0 Blake boiler feed-pump; will be connected on the suction side with the salt-water side of the distillers, and will discharge into the evaporators through suitable check-valves.

The circulating water, after passing through the distillers, will go forward through a $2\frac{1}{2}$-inch copper-pipe for use in flushing the heads; a $2\frac{1}{2}$-inch copper bye-pass pipe, fitted with suitable valves, will connect the discharge of the pump used to circulate water through the distillers with the pipe leading forward to the head, for use when from any cause the distillers are shut off.

The evaporators will be felted and lagged, and each will be fitted with a safety-valve, steam-gauge, glass water-gauge, salinometer-pot, and blow-valve; the pipes from the blow-valves to lead through ship's side, or to be connected to the bottom-blows in fire-room, as may be hereafter determined.

The distillers to be fitted with filters and with the pipes necessary for running the distilled water into the fresh-water tanks.

PUMP-CYLINDERS.

The water-cylinders of all steam-pumps will be made of composition, and will be fitted with relief-valves connecting the receiving with the delivery side of the pump, and suitably loaded for the service required in each case.

All pumps will have screw check-valves in suction and delivery-pipes close to pump-chambers, and stop-valves in both steam and exhaust-pipes. All suction-pipes leading to bilge, excepting those from the circulating-pumps, are to be fitted



with Macomb bilge-strainers. The steam-cylinders of all pumps, blowers, and other auxiliary machinery will have their exhaust-nozzles connected to an exhaust-main, which will pass through engine and fire-rooms. This main will be connected to both main-condensers and to the receivers of both engines, will also have a discharge into the atmosphere, and will be furnished with the necessary valves for governing the direction of the exhaust. Additionally, the main feed-pumps will be supplied with means of turning their exhaust steam into their feed suction-pipes.

### WORKING-PLATFORMS.

Working-platforms of wrought iron will be situated each side of the bulkhead, between the engines, convenient to which will be arranged all the handles, levers, and connections for operating the engines, with the counters, revolution indicators, clocks, steam, and vacuum-gauges in plain view.

Ladders will be provided as means of escape from engine-rooms when the water-tight doors are closed, and will be located on the bulkhead separating the engine compartments.

The engine-room stairway for ordinary use will be accessible from the berth-deck, through a door in engine-room hatch bulkhead, and will have its landing on the working-platform in the forward engine compartment. A door under this stairway will communicate with after engine compartment, and suitable footways will be arranged for access to the moving parts of the machinery, fitted, where required, with brass hand-rails and finished wrought-iron stanchions.

### FEED-WATER TANKS.

A feed-water tank will be placed in each engine-room over the air-pump, as shown in the drawings. These will be made of wrought iron not over $\frac{3}{16}$ inch in thickness, and will have a capacity of about 150 gallons. Each tank will be fitted as



a filter and be provided with a vapor-pipe, a float-valve for preventing access of air to feed-pump, an overflow-pipe, and a glass gauge.

A pipe of ample capacity will connect the tanks with each other, and will be furnished with a stop-valve for making or closing communication between the tanks.

A supply-pipe will lead from these tanks to the main feed-pumps in fire-rooms.

### LINE-SHAFTING.

The section of line-shafting of forward engine will be made of steel, finished 10 inches diameter, with coupling-discs 21 inches diameter and $2\frac{3}{4}$ inches thick at after end, and 4 inches thick at forward end. It will be about 20 feet and 6 inches in length, the actual length to be taken from the ship. It will have a $3\frac{1}{2}$-inch hole drilled axially through it, and will be supported about the middle of its length by a spring bearing. Where it passes through the engine-room bulkhead, a stuffing-box will be fitted as an additional bearing.

The line-shaft will be connected to the forward engine crank-shaft by a flexible coupling, and to the thrust section of shafting by six steel body-bound bolts $2\frac{1}{4}$ inches in diameter, with finished steel nuts.

### THRUST-SHAFTING.

The thrust sections of shafting, one for each engine, will be about 10 feet and 6 inches long, 10 inches diameter, with a coupling-disc forged on the forward end 21 inches diameter and 4 inches thick. The after end will be enlarged, and made with a socket bored $15\frac{1}{2}$ inches deep and tapering from 10 to 9 inches diameter, with suitable flanges for the coupling-bolts, which take the pull when backing.

Each shaft will have 12 raised collars for taking the thrust, $1\frac{1}{8}$ inches thick, except the end collars which will be $1\frac{3}{8}$ inches thick and $13\frac{1}{2}$ inches outside diameter, with spaces $1\frac{1}{4}$ inches



between them. The shafts will be made of steel and will each have a 3½-inch hole drilled axially through it.

The port section of thrust-shafting will be connected to the after engine crank-shaft by a flexible coupling; the starboard section to the line-shaft of forward engine by 6 body-bound steel-bolts, 2¼ inches diameter, with finished steel-nuts.

### PROPELLER-SHAFTING.

The propeller-shafting will be made of steel, turned 10 inches diameter, and made with the inboard ends to match the sockets, of the connecting shafts, to which they will be connected by feather-keys.

Each propeller-shaft will be about 51 feet long, the actual length to be taken from the ship, and will have a 3½-inch hole drilled axially through it. Each will be fitted with a disc collar 21 inches diameter and 3 inches thick, screwed on and coupled to the socket flanges by six steel-bolts 1¾ inches diameter.

Each shaft will be covered with a composition casing ½ inch thick, except where it rests in outside bracket-bearings, where it will be ¾ inch thick, finished on outside and extending from the coupling to 3 inches within the hub of the propeller; thence the shafts will taper from 10 inches to 9 inches in a length of 23 inches, and be fitted each with two steel keys 1¾ x 1¾ inches, placed opposite each other, and will have a thread turned on the end and be fitted with a composition closed nut, suitably locked, for taking the backing-thrust.

### SCREW-PROPELLERS.

The propellers are to be made of manganese bronze, about 11½ feet diameter; to have adjustable blades of such form and pitch as may be required, and to turn outward in forward motion.

### OUTSIDE AND STERN-PIPE BEARINGS.

The stern-pipes and outside-bearings will have composition bushings divided in halves, and fitted with lignumvitæ staves.



The bearings to be not less than 36 inches long, with the proper flanges for securing them in position.

### STERN-PIPE STUFFING-BOXES.

The stuffing-boxes are to be made of composition, with a packing space of 1 inch wide and 7 inches deep, fitted with followers made in two parts with a space of 1½ inches between them and properly secured in place by Tobin's metal bolts. Each stuffing-box will be placed wholly within the stern-pipe, properly secured, and made water-tight by suitable flanges on its inboard end.

### THRUST-BLOCKS AND BEARINGS.

The thrust-blocks are to be of cast-iron, made for a circulation of water through them, and fitted with composition thrust-rings 1¼ inches thick, arranged to match the rings and grooves of the shafts, the rings to be held from turning in their seats by chocks secured by the caps; the caps to be made with lugs locking into the blocks, also with ample oil and grease-cups with hinged covers, and fitted with tubes and wick-holders for each ring; the caps to be well secured in place by four wrought-iron bolts 1¾ inches diameter.

The blocks will rest on foundations built in the ship, to which they will be secured by four bolts, 2 inches diameter, and otherwise fitted with keys so that they can be accurately adjusted to line in any direction. (The above specification to be held subject to change by introducing a hydraulic registering device for showing the actual thrust on the shafting.)

### SPRING-BEARING.

The line-shafting of forward-engine, where it passes through after-engine compartment, will be supported from the center-engine keelson by a spring-bearing having a length of at least 12 inches.



### JACKING-WHEELS.

There is to be a cast-steel ring keyed on the periphery of the forward coupling of each thrust-shaft; to have an outside diameter of 33 inches and with 4 inches face, and to be drilled with fifteen 3-inch holes equispaced around the circle at a radius of 14 inches. The holes to be slightly tapered and smoothly reamed. Four steel pins will be required to fit the holes in jacking-wheels.

### FLEXIBLE COUPLINGS.

The crank-shafts of both engines will be connected to their respective sections of shafting by 10 steel-pins, $1\frac{3}{4}$ inches diameter where they pass through the crank-shaft coupling-discs, in which they will be secured by finished steel nuts with suitable locking-device, and $2\frac{1}{4}$ inches diameter where they project into the coupling-discs of thrust and line-shafting. These discs will stand off from the faces of crank-shaft coupling-discs about $\frac{1}{4}$ of an inch, and each pin will be fitted with an approved automatic lubricating device.

### FRICTION-BANDS AND WHEELS.

Steel friction bands 4 inches wide, with all the requisite connections are to be fitted to clamp the circumferences of the friction-wheels, which will be formed on the circumferences of the jacking-wheels.

### WATER-PIPES.

Seamless brass water-pipes, 3 inches diameter, are to be fitted, and have two connections, one with the sea and one with discharge of auxiliary pump, with the necessary valves in each engine-room.

They will have two branches of not less than $1\frac{1}{4}$ inches diameter to each main and crank-pin bearing; two branches



of 1 inch diameter to each cross-head slide; one branch of 1 inch diameter to each eccentric, and two branches 1¼ inches diameter to each thrust-bearing.

Also two of ¾-inch diameter, screwed into each crank-shaft pillow-block, with holes leading down through brasses to tops of journals.

All branch water-pipes will be fitted with cocks or valves for regulating the supply of water to bearings.

### JOURNAL-BOXES.

All journals or moving parts of iron or steel are to run in composition-boxes.

The crank-pin and crank-shaft boxes are to be lined with an approved anti-friction metal.

### INDICATOR-FITTINGS AND MOTIONS.

Indicator-connections for each end of each steam-cylinder and air-pump are to be fitted, as near as possible, to the bores of their cylinders, and so located as to be easily accessible.

The indicator-motions are to be so designed as to give the indicator-barrels motions coincident with those of the pistons.

### REVOLUTION-INDICATORS.

Revolution-indicators showing on suitable dials the speed and direction of the engines are to be placed in each engine room, and suitable dials for showing in which direction the engines are turning are to be placed in such part of the ship, on deck, as may be required.

### OIL-CUPS.

Each crank-pin will be fitted with a centrifugal oiling device as well as a telescopic or wiping arrangement, both to be of approved design. All crank-shaft bearings will have ample oil-cups with hinged covers, tube and wick-holders, and so arranged that the amount of oil passing down each tube to the journals can be seen and regulated. Wipers carried by the



upper ends of the eccentric-levers are to furnish oil for lubricating the eccentrics and all connections of the eccentric-levers. These wipers to take oil from strips of webbing or other approved device, supplied by oil-cups suitably supported and capable of adjustment so as to feed oil in all positions of the valve-gear, and also so arranged as to make the supply of oil to the various parts independently adjustable.

All other joints or moving parts not otherwise referred to, and especially the cross-head slides and the valve-connections are to have finished brass automatic oiling-gear of approved design, capable of supplying sufficient lubrication while the engines are in operation without waste of oil.

All oil-cups to be such as can be easily filled while the engines are running at maximum speed, and to have an oil capacity for at least four hours running.

All fixed bearings to have drip-cups cast on where possible, otherwise to be made of cast-brass and properly fitted.

All such cups to have drain pipes and cocks of at least ½ inch diameter, which can be used while the engines are in operation.

All moving bearings are to have drip-cups or pans of sheet brass where necessary.

### HOLES THROUGH SHIP.

All holes through the ship are to be covered by cocks or valves on the inside, and to be fitted with zinc protecting rings if required.

### PUMP—CONNECTIONS TO FIRE-MAIN.

The fire and bilge, and auxiliary feed-pumps will each have a discharge-pipe, with straightway stop-valve, connecting it with the fire-main running fore and aft, and a branch from each discharge-pipe near the pump will be fitted with standard hose-connection and straightway-valve.



### EYE-BOLTS.

Wrought-iron eye-bolts and traveler-bars are to be properly located and secured wherever required for lifting different parts of machinery, and particularly the covers of cylinders and valve-chests, the covers of air and circulating-pumps and their valve-chests, the condenser-bonnets, the connecting-rods, the caps of pillow-blocks of crank-shaft and line-shaft journals and of thrust-bearings.

### SECURING ENGINES IN SHIP.

The engines will be adjusted and lined upon the engine-keelsons by means of wooden wedges driven from both sides of the bearing-surfaces, and when accurately in line the spaces around holding-down bolts between sole-plates and keelsons will be filled by accurately fitting wrought-iron horse-shoe washers, upon which the holding-down bolts will be set up and locked in place.

### STEERING-ENGINE.

A steering-engine of the Williamson type will be supplied and fitted where shown on the plans. It should be of the latest type to work by hand or steam-power, and of sufficient power to put the rudder from amidships to hard-over in 12 seconds when the vessel is going ahead at the rate of 16 knots per hour. The engine contractors will fit and secure the engine, supply the steering-wheels directly attached to it, make the steam and exhaust-connections, and supply and fit the whole main-shaft and sprocket-wheel; but all deck-wheels, and all rods and gear for actuating the valves from the deck are to be fitted by the hull contractors who will also cut all holes in the decks and bulkheads for securing the engine and running the shaft, &c. Where the shaft passes through bulkheads, brass stuffing-boxes will be fitted water-tight. All journals are to be in brass bearings and fitted with self-feeding oil-cups.



### STEAM-WINDLASS AND CAPSTAN.

A steam-windlass of approved pattern, suitable for 1½-inch chain, will be supplied and fitted. It will be located on the main deck under the forecastle, where shown on the plans of the hull, and will have a capstan attachment on the deck above. Both capstan and windlass should work by either hand or steam power. The steam-cylinders, which should be of sufficient size to raise both anchors at once at the rate of 6 fathoms per minute, with steam-pressure of 30 pounds by gauge, must have reversing-gear, and be located upon the main deck. Steam and exhaust-connections will be made and all fittings, capstan bars, and spare parts supplied complete.

The contractors for the hull will make all holes in the decks for securing the windlass and capstan, and will stow the fittings, &c.

### DRAIN-PIPES AND TRAPS.

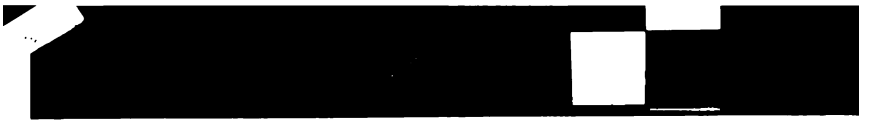
All receptacles where condensed steam is likely to accumulate will be provided with drain-pipes and cocks of ample capacity leading to automatic traps (fitted with bye-pass pipes and valves), which will discharge into feed-tanks.

The drain-pipes from safety-valves are to be connected at least ½ inch below the level of valve-seats.

### BOILERS AND ATTACHMENTS.

There are to be four horizontal tubular boilers placed forward of the engines, in pairs longitudinally, one pair forward and one pair abaft an athwart-ship bulkhead passing under the center of the smoke-pipe. The boilers are to carry a working pressure of 100 pounds by gauge. There will be two athwart-ship fire-rooms, one forward of the forward boilers and one abaft the after boilers.

There is to be one fixed smoke-pipe in vertical plane over the keel, connecting with an uptake common to the four boilers. The boilers are to be constructed of open hearth





steel. All plates are to be planed on their edges, and thoroughly calked inside and out wherever accessible. Butt-jointed seams are to be covered with straps, and all rivet-holes are to be either drilled to full size or be punched $\frac{1}{8}$ of an inch small and reamed in place to proper size. Each boiler is to be 10 feet in diameter outside and 16 feet long, and to have three furnaces $38\frac{1}{2}$ inches least internal diameter, projecting $3\frac{1}{4}$ inches from front of boiler and extending to combustion-chamber.

GRATE-SURFACE.

Each furnace is to have a grate $38\frac{1}{2}$ inches wide and 75 inches long, or 20 feet in area, aggregating 240 feet in the four boilers.

GRATE-BARS.

The grate-bars to be of wrought-iron, in one length, of approved pattern. They will be arranged to be shaken by proper tools at front end; these tools to be furnished. The furnace-fronts, bridge-walls, and bearers to be properly fitted to support the bars.

TUBES.

Each boiler is to contain three hundred and eighty lap-welded wrought-iron tubes. Every third tube, vertically and horizontally, is to be a stay-tube; and will be $\frac{1}{4}$ inch thick and $2\frac{1}{2}$ inches external diameter. The other tubes will be No. 11 B. W. G. in thickness, $2\frac{3}{4}$ inches external diameter, and will be enlarged to $2\frac{13}{16}$ inches on that end which is secured to the tube-sheet through which they must pass when being removed.

The stay-tubes will be screwed into both heads, the back ends to be swelled to $2\frac{3}{4}$ inches diameter and be fitted with a nut on the outside of head. This method of setting is subject to change if so directed.



### SHELLS.

The shells are to be of plates $\frac{5}{8}$ inch thick, the longitudinal joints to be double-strapped and treble-riveted each side of seams, the proportion of joint to be as shown on drawing. The circular-joints to be single-strapped and double-riveted. The shells will depart from the circular form at each end on top, where they will be rounded to quadrants, the radius of which is $32\frac{3}{4}$ inches.

### TUBE-SHEETS.

The tube-sheets are to be $\frac{5}{8}$ inch in thickness, and are to be accurately drilled for three hundred and eighty tubes, spaced $3\frac{3}{4}$ inches between centers vertically and horizontally. The distance between insides of sheets is to be 6 feet $10\frac{3}{4}$ inches.

### HEADS AND BRACES.

The heads are to be $\frac{5}{8}$ inch thick. The upper portions of the heads will be braced by a row of eight braces 2 inches in diameter, 12 inches between centers, and $24\frac{3}{4}$ inches above center line of boiler; the braces to be of mild steel without welds in length or eyes. The braces will be made as shown in drawings, with nuts on both sides of boiler-heads; having raised threads on ends.

There are to be two $1\frac{3}{4}$-inch braces between the front head and furnace plate of combustion-chamber, secured to head by studs and coupled to two angle-irons, running across the combustion-chamber plate, by $1\frac{3}{4}$-inch pins. Four $1\frac{3}{4}$-inch diagonal braces are to be fitted, one on each side of each lower man-hole, to be secured to head by nut and washer, and to shell by four rivets; the combined shearing strength of rivets to exceed tensile strength of brace by 25 per cent. Two rows of $1\frac{3}{8}$-inch braces, 13 in each row, stay the top of combustion-chamber to shell. These braces are spaced 8 inches between centers, and are to be connected by $1\frac{1}{8}$-inch pins to jaws of studs on combustion-chamber, and, by pins of the same size, to double angle-irons on shell.



FURNACES.

The furnaces are to be of the best steel, welded at joints and corrugated. They are to be 38½ inches diameter at the inside of corrugation, ⅜ inch thick, and are to be single-riveted at their junctions with front heads and combustion-chambers.

BRIDGE-WALLS.

A bridge-wall of approved pattern will be fitted in each furnace. The upper part will be finished with fire-brick. The lower part, below the grate-bars to be furnished with an inclined hinged door at least 6 inches high and as wide as possible, so made as to be easily opened and shut from fire-room. The bridge-walls to be easily removable.

COMBUSTION-CHAMBERS.

The combustion-chambers are to be 24 inches deep; the sides and tops to be ½ inch thick; the ends, furnace-plates, and tube-sheets to be ⅝ inch thick. The sides to be stayed by steel-screw stay-bolts 1⅜ inch least diameter, spaced not over 8 inches from center to center.

STAY-DOMES.

There are to be three ⅝ inch thick stay-domes on furnace-plates of combustion-chamber, opposite man-hole plates in heads, to have an outside radius of 5½ inches; and one on each inside tube-sheet, opposite back man-hole plate, having an outside radius of 6½ inches.

BACK CONNECTIONS AND UPTAKES.

The back connections and uptakes are to be made with double shells of wrought iron, built on frames of 2½ x 1½ inches channel iron, the space between to be filled with an



approved non-conducting substance. The inside and outside shells to be made of iron weighing, respectively, 6 pounds and 4 pounds per square foot.

The uptakes of each pair of boilers will pass upwards independently to the height of the water-tight bulkhead, across which they will be united. They will also be so divided that the gases from each boiler will have a separate passage to its own compartment of the smoke-pipe.

The connection doors are to be made of wrought iron with double shells, and fitted with hinges and catches of wrought or malleable iron. The outside shell is to be $\frac{1}{4}$ inch thick, and the lining $\frac{1}{8}$ inch thick. The outer shell to be flanged 1 inch deep, and the inner one $2\frac{1}{4}$ inches deep.

### FURNACE FRONTS.

The furnace fronts are to be made with a channel-iron frame covered with wrought-iron plates, $\frac{1}{4}$ inch thick on the inside and $\frac{3}{8}$ inch thick on the outside; both plates to be suitably perforated for air-entry, if so directed.

### FURNACE DOORS.

The furnace doors are to be of wrought-iron $\frac{1}{4}$ inch thick, and flanged 1 inch deep; each to be fitted with a perforated wrought-iron inner-plate, and provided with wrought-iron hinges, air-regulators, and catches.

### ASH-PIT DOORS.

The ash-pit doors are to be of wrought iron $\frac{1}{8}$ inch thick, flanged 1 inch deep, and fitted to place so as to thoroughly close the ash-pits, and to fit lugs on bulkhead when not in use.

### MAN-HOLES.

There are to be three 12 x 15 inches man-holes in the front head of each boiler, one under each wing furnace and one above middle furnace; each to be stiffened with a circumferential strap, as shown in drawings.



There is to be one man-hole 12 x 15 inches in lower part of back tube-sheet of each boiler; to have an inside strap 3 x $\frac{3}{4}$ inches. These holes are to be covered by appropriate plates with cross-bars, bolts, and nuts.

SADDLES.

Each boiler is to rest on three saddles which are to be built in and form part of the hull. The boilers are to be secured by double angle-irons riveted to boilers and saddles.

SMOKE-PIPE.

The smoke-pipe is to be 55 feet in total height above the upper grates. It is to be 7 feet 6 inches in diameter, made of wrought-iron plates; the lower courses to be No. 7 B. W. G. thickness, the upper ones No. 8. The pipe is to be stiffened by angle-iron bands on the inside, at top and bottom, and by a band 4 inches wide and 1 inch thick on outside at top. The pipe will be inclosed throughout its length by a jacket leaving an annular space of at least 3 inches. The jacket to be of wrought-iron $\frac{1}{8}$ inch thick and to be covered by a hood with sufficient space for the escape of hot air. The pipe and jacket are to be made with strapped butt joints. The pipe will be provided with stays, eyes, and shackles, and will be supported in such a manner as to relieve the uptakes of its weight. The pipe will have fore-and-aft and athwartship partitions running from bottom to top. A pivoted damper will be fitted in each compartment of the pipe, near the top; to serve also as a cover. Drain-troughs to be fitted below the dampers so as to catch all water passing them when closed, with drain-pipes leading where directed. Each damper to be worked from the fire-room, containing the boiler which it controls, by approved mechanism. A permanent ladder reaching to the top of smoke-pipe will be fitted as directed.



STEAM-DRUMS.

There are to be two steam-drums placed in the spandrels above the boilers, each to be 3 feet in diameter and 11 feet 9 inches long; the shells to be $\frac{5}{16}$ inch, and heads $\frac{7}{16}$ inch thick; the heads to be braced by gussets or stay-rods.

DRY-PIPES.

Each boiler is to have a properly perforated tinned brass dry-pipe closed at the internal end, of the same diameter as the steam-pipe with which it is connected. It is to be placed as high as possible, and extend nearly the length of the boiler. Its upper surface is to be pierced with holes $\frac{3}{8}$ inch in diameter spaced equidistant, their aggregate area to be twice that of the cross-section of the pipe.

CIRCULATING-PLATES.

Circulating-plates of galvanized wrought iron will be fitted in the boilers, as directed.

FELTING.

After the boilers are in place in the vessel and have been tested under steam, their shells and fronts are to be covered with asbestos quilting, containing a layer of felt $1\frac{1}{4}$ inches thick, or with other approved material, as may be directed, which will be protected by a galvanized iron covering, the joints of which will be lapped and bolted. The iron is to be painted with two coats of brown zinc paint.

SAFETY-VALVES.

Each boiler is to have an automatic spring safety-valve, $5\frac{1}{2}$ inches in diameter, adapted to a maximum pressure of 100 pounds per gauge, and fitted with proper levers and approved mechanism for working them from the fire-rooms. The chests, valves, and stems are to be of composition, and the seats of nickel.



The chests are to be bolted to the stop-valve chambers, and to be connected by copper pipes to the escape-pipes, which will also be of copper. The escape-pipes are to be furnished with mufflers. The seats of all safety-valves will be at least ½ inch above the bottom of their chests.

### SENTINEL-VALVES.

There is to be a sentinel-valve of ½ square inch area attached to the front of each boiler, fitted with movable weight and notched lever, and weighted to close tightly against a boiler-pressure of 150 pounds per square inch.

### STEAM-WHISTLE.

A composition steam-whistle, the bell of 6 inches diameter, is to be placed forward of the smoke-pipe, well above the level of the deck-awning, and connected with the main steam-pipe by a copper pipe having at its lower end a valve of appropriate kind and size, and a working-valve at upper end.

### WATER-GAUGES.

Each boiler is to have on its front two composition water-gauges carrying glasses 16 inches in exposed length, and with outside pipe-connections to top and bottom of boiler, the bottom of glass being 1 inch below the highest heating surface.

There shall also be four gauge-cocks placed 4 inches apart, the lowest cock to be placed 4 inches below the highest heating surface of the boiler. The glass gauges and the column for the cocks will be independent of each other. The cocks will be supplied with drip-pans and drain-pipes.

### SALINOMETER POTS.

There is to be a salinometer pot of approved pattern on each boiler, fitted in an accessible position.



### BOILER–TEST.

Before being placed in the vessel, all the boilers are to be tested under a pressure of 150 pounds by gauge. This pressure to be obtained by the application of heat to water within the boilers, which are to be filled quite full. After a satisfactory test, the boilers are to be painted on outside with two coats of brown zinc paint.

### AUXILIARY STEAM–PIPES AND VALVES.

Each boiler stop-valve chamber will have an auxiliary stop-valve bolted to the nozzle on its side and under the main-valve. These valves are to be connected by an auxiliary steam-pipe of 4½ inches internal diameter, with suitable branches leading to the pumps, heaters, distillers, evaporators, and auxiliary engines.

A branch-pipe with stop-valve will connect main and auxiliary steam-pipes in each engine-room.

### BLEEDER.

There is to be a copper pipe, with stop-valve at each end, 3½ inches in diameter, leading from the main steam-pipe to each condenser. One valve in each engine-room to be worked from working platform.

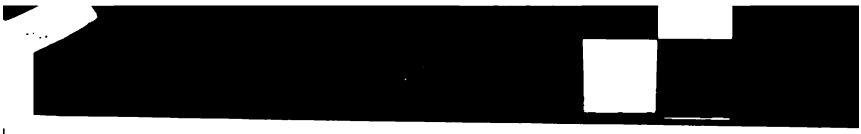
### CHECK–VALVES.

Each boiler is to have two feed check-valves, 2½ inches in diameter, having outside screw-threads on their stems; chambers, valves, and stems to be made of composition.

All check-valves to have internal pipes, to direct the water downward after it enters the boilers.

### BLOW–VALVES.

Each boiler is to have a bottom blow-valve of composition 2½ inches in diameter; also a surface blow-valve 1½ inches in diameter. These valves are to be connected by suitable pipes to the sea-valves.





The bottom blow-valves are to have internal pipes leading toward the bottoms of boilers, the surface blow-valves to have pipes leading to the centers of boilers, with openings about 1 inch above the highest heating surface.

### FEED AND BLOW-PIPES.

The main feed and blow-pipes are to be made of seamless drawn brass tubes, 4 inches in internal diameter, and in sections not exceeding 12 feet in length. The branches to be of copper or brass, as may be directed, of the same thickness. All elbows, nozzles, turns, and flanges are to be of composition. The several sections are to have flanges riveted to their ends, brazed and calked. All flanges to be united by forged bolts and nuts of Tobin's metal. Suitable provision for the expansion of these pipes will be supplied.

### BOILER STOP-VALVES.

Each boiler is to have a composition stop-valve chamber combined with safety-valve chamber, placed on the front head near the top, united with the boiler and dry-pipe by flanges of suitable size and thickness, and having on its side a nozzle under the valve to which the auxiliary stop-valve will be connected. The valve in stop-valve chamber is to be 8 inches in diameter, fitted with a screw-stem of composition, and made to turn independently of the valve, and to work in a composition nut, supported by wrought-iron studs screwed into the cover. The valve is to be operated by a composition hand-wheel 14 inches in diameter. Separate provision is to be made for working the stop-valves from above the protective deck.

### DRUM STOP-VALVES.

There will be two automatic screw stop-valves attached in a horizontal position to a nozzle bolted to each steam-drum, to be operated from above and below the protective-deck, with their chests, valves, and stems of composition. They will be 10 inches diameter, and open only the necessary amount to give an area equal to that of the opening under the valve.



### STEAM-PIPES.

The steam-pipes leading to each drum are to be 10½ inches in internal diameter. The main steam-pipe from its junction with the pipes leading from the drum to the separator, and from the separator to the branch-pipe leading to the forward engine to be 13½ inches internal diameter. From this point the pipes leading to the forward and after engines to be 10½ inches internal diameter. These pipes are to be of copper, the several sections to be united to each other and to the drums, separator, and valve-chambers by composition flanges of suitable size and thickness, riveted on and properly brazed. Where these pipes pass through water-tight bulkheads they are to be provided with approved expansion joints. The steam-pipes and flanges to be covered with asbestos quilting containing a layer of felt 1¼ inches thick, which will be covered and protected with an approved water-tight covering; this covering to be secured to bulkheads where the pipes pass through them.

The connections between boiler stop-valves and steam-drums to be made by copper pipes 8½ inches in diameter; sections to be connected as in main steam-pipes.

### EMERGENCY STEAM-PIPES.

An emergency system of steam-pipes, duplicate of the main steam-pipes, will lead on the port side of the vessel from the steam-drums to the steam-pipe in the forward engine-room, as shown in the drawings.

They will be fitted with the necessary valves to enable each system to be used independently of the other; these valves to be operated from above and below the protective-deck.

### ESCAPE-PIPES.

There will be two escape-pipes of copper, one forward and one abaft the smoke-pipe, extending to the top of the pipe and secured to it.



### PIPE-CLOTHING.

All main and auxiliary steam-pipes, exhaust-pipes, where directed, the separator, and all steam-valves, are to be clothed with an approved non-conducting material, covered with canvas in double thickness, well painted. The covering to be secured to bulkheads where the pipes pass through them. The pipes are also to be covered with black walnut lagging with brass bands where directed.

### PIPES THROUGH BULKHEADS.

All pipes where they pass through water-tight bulkheads will be provided with stuffing-boxes, or made tight in other approved manner.

### BOILER DRAIN-COCKS.

There will be a drain-cock having $1\frac{1}{2}$ inches diameter of opening, fitted to each end of each boiler.

### SEPARATOR.

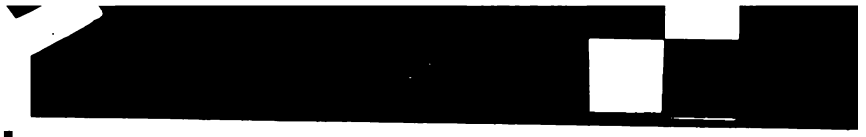
There is to be a separator in the steam-pipe of approved kind, to be placed as shown in the drawing; it will be fitted with a suitable drain-pipe and valve, and a water gauge glass on the side.

### FLOOR-PLATES.

The fire and engine-rooms and their passages, are to be floored with wrought-iron plates having corrugations on the upper surface and proper ledges and drain-holes. They are to be of wrought iron not less than $\frac{1}{4}$ inch thick, and all easily removable.

### BLOWERS.

The fire-rooms are to be supplied with air by means of Sturtevant blowers or their equivalent, two to each fire-room. Each blower is to be driven by its own engines direct, and to be capable of supplying, with ease and certainty, 12,000





cubic feet of air per minute, under a pressure of 4 inches of water. One of the after-blowers is to be fitted to take its air from the engine-rooms as well as from deck.

### VENTILATORS.

Four ventilators, each 24 inches in diameter, are to be fitted, two in each fire-room. They are to deliver air to the inlet of the blowers placed under them. They are to have movable hoods, and will be made of iron $\frac{1}{8}$ inch thick above the spar-deck, and of iron No. 11 B. W. G. below it. The gears for turning the hoods will be of composition. Additionally, there will be in the corners of the boiler-hatch four ventilators, placed outside of the pipe-jacket; they will be 21 inches in diameter inside, made with movable hoods worked from deck. They will discharge the air downwards through the grating of the hatch, and beneath the protective-deck will be arranged to deflect the air outwards.

### ASH-HOISTS.

There will be an ash-hoist 21 inches in diameter for each fire-room, as shown in general plan of machinery. They are to be of iron $\frac{1}{8}$ inch thick, butt-strapped on the outside, and flush-riveted on the inside. They are to be fitted with appropriate appliances for sustaining the upper block of the ash-whip, and a means for closing them when an air-pressure is required in the fire-room.

There will be an approved ash-hoisting engine for each fire-room, of suitable dimensions of cylinder to hoist 150 pounds with 20 pounds steam-pressure. They will be fitted with all necessary connections, including whip, and with a suitable brake to control the drum.

### AIR-TIGHT FIRE-ROOMS.

Supplementary bulkheads and ceilings of light galvanized iron are to be fitted in the fire-rooms for the purpose of



reducing the capacity of the space to be put under air-pressure. The ceiling is to be made movable beneath hatches. The vertical portion to be provided with openings where passage-ways are required, with suitable means for closing them.

All permanent and temporary joints and seams to be made perfectly air-tight.

### STEAM-JET.

A steam-jet of approved capacity and design will be provided and fitted in the smoke-pipe.

### HYDROKINETER.

There will be connected to each boiler a Weir's hydrokineter, or other approved appliance for circulating water in the boiler while raising steam, proper connections being made to auxiliary steam-pipe.

### TESTS OF MATERIAL.

All material used in the construction of the boilers, connecting-rods, crank-shafts, line, thrust, and propeller-shafting, will be tested in accordance with the "Instructions to Inspectors," a copy of which is appended to these specifications.

### DUPLICATE PIECES.

All duplicate pieces are to be finished and fitted ready for use. They are to be as follows, viz:

One set of valves and springs for each steam-pump.

One seat, with guards and bolts complete, for receiving-valves and one for delivery-valves of air-pump.

One-half set of follower bolts and nuts for each steam piston, and one-half set for each air-pump piston.

One set of brasses for each crank-shaft journal.

One set of brasses for each crank-pin and cross-head journal.

One brass slipper for each cross-head.

One set of brasses for each adjustable connection of each valve-gear.



One set of brasses for each thrust-bearing.

Two hundred condenser-tubes packed in boxes.

Forty stay-tubes, threaded to fit threads in tube-sheets, and 100 plain boiler-tubes, swelled at one end and annealed. The ends of stay-tubes to be wrapped in canvas. All boiler-tubes to be securely stowed in racks or as directed.

Forty stay-tube nuts.

One spare basket for each Macomb's strainer.

One-eighth of a set of grate-bars.

All duplicate pieces not of brass, to be painted with three coats of white lead and oil, and well lashed in tarred canvas, with name marked in black paint on the outside.

Brass pieces to be marked or stamped.

### OIL-TANKS, CANS, ETC.

Four oil-tanks of iron $\frac{1}{8}$ of an inch thick, with an aggregate capacity of 500 gallons, are to be well secured in oil store-room, with facilities for filling them from deck. The tanks are to be strengthened by internal stays, if directed. Each tank will have a man-hole near the top closed by a plate, and will be fitted with a locked cock for drawing oil.

Four copper oil-tanks of 10 gallons capacity each, with lids and drip-pans, to be placed permanently in the engine-rooms, in convenient positions, and to have a locked brass cock on each.

An iron tallow-tank of 100 pounds capacity, with hinged cover, will be fitted in one engine-room.

### INSTRUMENTS, TOOLS, ETC.

Eight Thompson's indicators of standard size, of the latest pattern made by the American Steam Gauge Company, each to be fitted with two springs, one graduated to a scale of 40 pounds to the inch, and one to a scale of 16 pounds to the inch, with proper attachments of finished brass, are to be furnished, ready fitted; also an extra cock-attachment for each indicator. Each



indicator stand-pipe is to be connected (separately) and with but one end of main cylinder, by a pipe one inch diameter, having a cock of equal area of opening.

Two sets of instruments, with proper attachments, each instrument in its own case, which will be of brass, as follows, viz:

One Lane's improved spring steam-gauge.

One Lane's improved spring compound-gauge.

One Lane's improved spring vacuum-gauge.

One continuous counter, with positive motion, to register from 1 to 1,( 00,000.

One eight-day clock with second-hand.

Faces of all spring-gauges and clocks to be at least 8½ inches diameter.

One mercurial vacuum-gauge attached immediately to condenser.

The above list to be considered as one set.

There will be four Lane's improved spring-gauges, one for each boiler, with 8½-inch face, and graduated to 150 pounds.

Each gauge will be properly secured in the fire-room, and have an independent connection to its boiler.

Eight thermometers, one for each hot-well or feed-tank, one in each outboard delivery-pipe, one for each injection, and one for each steam-pipe close to the engines, to be made permanent fixtures, with their stems and bulbs protected by brass covers; also two spare steam-thermometers, two spare water-thermometers, and one standardized thermometer in suitable case.

An engine-room telegraph of approved design, with reply-gongs and any number of dials that may be required, to be supplied and fitted for each pair of engines. Telegraphs of approved pattern are to be fitted to put engine-rooms and fire-rooms in communication.

Two complete sets of fire-irons for each fire-room, with suitable racks for stowing.

Lazy bars for each boiler to be fitted in place.



One set of wrenches complete for each engine, to be fitted to all the nuts, finished and marked with size, and placed in iron racks. Wrenches for all nuts of bolts two inches in diameter and over to be box-wrenches, where such can be used.

One pair of taps, on rod, for tapping front and back tube-sheets at one operation. This be a duplicate of the tool used in originally tapping the sheets, and to be packed so as to be perfectly protected from injury.

A steam tube-cleaner of approved design with fittings and connections complete. To be of sufficient length to clean the tubes from the fire-room end, through furnaces or ash-pits. To be fitted with a wooden handle, and stowed in a convenient rack in fire-room. A spare nozzle, and flexible steam-pipe to be furnished.

Twelve ash-buckets.

Twelve coal-buckets.

SCHEDULE OF THICKNESS OF COPPER AND BRASS PIPES, B. W. G.

| | Number. |
|---|---|
| Main and branch steam-pipes | 5 |
| Air-pump discharge | 8 |
| Jet-injection | 16 |
| Circulating suction and discharge | 8 |
| Bilge-suction and delivery | 11 |
| Blow-pipes | 7 |
| Main exhaust | 10 |
| Auxiliary steam-pipes | 11 |
| Main and auxiliary feed-delivery | 11 |
| Main and auxiliary feed-suction | 11 |
| Waste steam-pipes and auxiliary exhausts | 12 |
| Dry pipes | 14 |

All bends are to be made one gauge thicker than straight part of pipe. All tee-pieces for brass pipes to be of composition.

Expansion-joints are to be fitted to pipes wherever required.



### JACKET STEAM-VALVES.

Steam for cylinder-jackets will be taken from the main steam-pipe with a valve in each branch. There will be an adjustable reducing-valve in the pipe taking steam to each low-pressure cylinder-jacket.

### SECURING CRANK-SHAFT AND CRANK-PIN BRASSES.

The top and bottom lips of crank-pin brasses will be secured to connecting-rod ends or caps, each by two 1¼-inch wrought-iron tap-bolts, tapped into lips of brasses near each end. The heads of these bolts to be recessed into rods or caps and secured by set screws. The lips of crank-shaft brasses will also be secured in an approved manner to prevent the brasses closing in when heated.

### AUXILIARY EXHAUST TO ESCAPE-PIPES.

Where the auxiliary exhaust main is connected to the escape-pipes, it will have two stop-valves, close together, for each connection.

### ASH-SPRINKLERS.

There will be on athwart-ship bulkheads of fire-rooms, opposite each boiler, about four feet from floor, a brass nozzle with universal joint, with valve and sea connection for wetting ashes. This to be of approved design and to be secured alongside bulkhead when not in use.



### RADIATORS.

Steam radiators of the following numbers and superficial area for the several parts of the ship will be provided, viz:

For the cabin 5, aggregating 90 square feet.

For the wardroom 2, aggregating 40 square feet.

For the steerage-country 3, aggregating 46 square feet.

For the berth-deck 3, aggregating 80 square feet.

Each radiator will be divided into as many separate and distinct parts as may be directed; each part to have its own steam and drain-valve. The steam and drain-pipes are to be seamless drawn brass, of iron-pipe size, suitably connected by composition elbows, tees, and unions, in a manner that will enable them to be easily taken down for repairs.

There will be reducing-valves in these pipes at the boiler-connections to regulate the pressure, and the drains will lead to such water-collectors as may be designated, or where preferred, overboard.

### MATERIALS AND WORKMANSHIP.

All materials used in the construction of the machinery are to be of the best quality. The iron castings to be of the best pig-iron (not scrap). The brass castings to be made of new materials of best quality. For all journal-boxes and guide-gibs the composition to be by weight 6 parts copper, 1 part of tin, and ¼ of one part of zinc. Where Tobin's metal is specified, the composition to be 58.22 parts copper, 39.48 parts zinc, 2.30 parts tin. For all other brass-work the composition to be 88 parts copper, 10 parts tin, and 2 parts zinc. All iron castings to be smooth and true to form, and before being painted to be well cleansed of sand and scale, and all fins and roughness removed.

All boiler-plates to be thoroughly cleansed of oxide-of-iron scale. Brass castings to be sound, smooth, and true. No imperfect casting or unsound forging will be used if the imperfection affects the strength, or, to a marked degree, its sightliness.



All steam, exhaust, and other pipes leading to and from steering and other engines, distillers, and pumps are to be of sufficient size for their respective objects, and to have expansion-joints where directed.

All copper pipes not seamless drawn are to be brazed, and all copper pipes are to have composition flanges riveted on, calked on both sides, and brazed. All pipes, not otherwise specified, to be of copper, and all pipes beneath floor-plates to be connected by forged bolts and nuts of Tobin's metal. All nuts on rough castings to fit facings raised above the surface. All pipes beneath floor-plates to be covered as directed, and care taken that they do not come in contact with the plates or frames of hull.

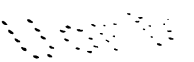
The work to be in every respect of the first quality, and executed in a workmanlike and substantial manner.

All flanges to be faced and grooved. All bolt-holes in permanently fixed parts to be reamed, and the body of the bolts to be finished to fit them snugly. All threads on bolts to correspond to the Navy standard. All brasses to fit loosely between collars of shafting. All cocks communicating with vacuum-spaces to have bottom of shell cast in, and to have the plug packed by means of a stuffing-box and follower. All nuts on moving-parts and on pillow-blocks to be thoroughly secured with keepers, pins, or steel set-screws. All brasses or journals to be properly channeled for the proper distribution of oil. All flanges coupled together to be faced and edges made fair with each other. Metallic packing for stuffing-boxes to be such as may be approved.

The cylinder-casings, condensers, and all tubes and pipes are to be tested for tightness before being placed in the ship.

All engine-work not finished to be primed with two coats of brown zinc and oil, and when placed in position on board the vessel will be painted with two coats of paint of approved color.

The line-shafting is to be painted when in place with two coats of white-lead and oil, and the boiler fronts with two coats





of lamp-black and oil. The smoke-pipe is to be thoroughly painted both before and after its erection on board the vessel.

All steam-pipes not lagged will be painted white, exhaust-pipes green, water-supply pipes red, and water discharge-pipes, lead-color.

All materials and parts of the machinery shall be carefully weighed by the contractor, when ready to go on board the vessel, and a record of the weights in detail furnished to the inspector, certified to by him, and reported to the Bureau of Steam Engineering.

While the engines and boilers are being completed, steam shall be raised in the boilers whenever required to test the connections, the working of all parts of the main engines and boilers, and all auxiliaries. All expense of such preliminary tests will be borne by the contractor.

Any portion of the work, whether partially or entirely completed, found defective must be removed and satisfactorily replaced without extra charge.

All drawings necessary during the progress of the work must be prepared by and at the expense of the contractor. Those which are merely developments of the official drawings and working-plans in accordance with the specifications will be subject to the approval of the Engineer-in-Chief or of the Inspector of Machinery, as may be directed, before the work is ordered or commenced. All plans involving changes or modifications of the original drawings must be approved by the Engineer-in-Chief. A complete set of drawings of the machinery as fitted must be furnished by the contractor, certified to by the Inspector of Machinery, and forwarded to the Bureau of Steam Engineering immediately upon completion of the work.

A suitable office and draughting-room, properly fitted and heated, for the use of the Inspector of Machinery and his assistants during the building of the machinery, is to be furnished by the contractor.

The contractors for the hull will supply the labor to fit the engine and boiler keelsons to the engines and boilers, and similarly for all auxiliaries.

All parts of machinery and boilers are to be secured, in an approved manner, to prevent displacement when the vessel is used for ramming.

The engines, boilers, uptakes, and smoke-pipe, all auxiliaries, their piping and connections, and all sea-valves, except the cutting of the holes for the same, and all parts described in these specifications and official drawings are to be fitted complete to the ship by the engine contractors; and any part of the machinery or any article pertaining thereto which may have been inadvertently omitted from these specifications or from the official drawings, but which is necessary for the proper completion of the vessel, is to be supplied by the contractor without extra charge.

# ADDENDA.

## MACHINERY SPECIFICATIONS FOR GUNBOAT OF 1,700 TONS DISPLACEMENT.

## (GUNBOAT No. 1.)

### ASH-HOISTS.

From each ash-hoist, on the upper deck, permanent overhead rails, suitably supported, will lead to the nearest ash-chute on each side of ship. Each of these will be fitted with a traveler of approved design, with all necessary appliances for carrying the ash-buckets. At the top of each ash-chute a dumping-hopper will be fitted, so arranged as to fold up out of the way when not in use. The ash-buckets are to be balanced dump-buckets with gear complete. All of the ash-hoisting and dumping-gear is to be such that the buckets will not have to be lifted by hand. A speaking-tube will lead from the top of each ash-hoist to fire-room.

### AUXILIARY STEAM-PIPES.

A steam-gauge in brass case, with 6-inch dial, will be attached to the auxiliary steam-pipe in each engine-room and each fire-room; also at windlass and steering-engine.

### FURNACES.

Ash-pans of ¼-inch wrought-iron will be fitted in all furnace-flues, reaching from front to bridge-wall.

### GRATE-BARS.

Cast-iron grate-bars will be fitted at the sides of furnaces to fit the corrugations.

### INSTRUMENTS AND TOOLS.

A gauge of approved pattern will be fitted in each fire-room to show the excess of air-pressure over the pressure of the open atmosphere. A portable air-pressure gauge will also be supplied to each fire-room, with connections for attaching it to the furnaces, uptakes, and where directed, to measure the pressure as compared with the air-pressure in the fire-room. All of these gauges to indicate pressures in "inches of water."

A set of wrenches fitting all nuts in fire-rooms is to be supplied to each fire-room, placed in iron racks.

Fixed trammels or gauges are to be supplied for lining up crank-shafts horizontally and vertically, marks for this purpose being made on brass plates let into pillow-block frames.



MATERIALS AND WORKMANSHIP.

All flanged boiler-plates are to be annealed in an approved manner after flanging.

The steam cylinders of all auxiliary engines are to be clothed and lagged the same as main cylinders.

All cocks are to have engraved brass plates to show their use and whether open or shut. All valve-wheels will be of composition, and will be plainly engraved to show their use, as will also all working levers and all gear for working valves from deck.

OIL-TANKS.

A copper oil-tank of 5 gallons capacity, with drip-pan, will be fitted in each fire-room.

PIPES.

All pipes passing through coal-bunkers will be cased in.

RADIATORS.

A radiator with 4 square feet of surface will be fitted in the wheel-house, one of 2 square feet in the executive officer's office, and such a number as may be directed, with a total of 90 square feet, under the forecastle.

STERN-BEARINGS.

A light steel sleeve will lead from after end of each stern-tube to the hub of propeller, forming a fair water-line.

All lignumvitæ is to bear on end of grain.

EVAPORATORS AND DISTILLERS.

The evaporators will take steam from the auxiliary steam-pipe and will be fitted with automatic traps and with drain-pipes leading to feed-tank, or as directed.

VENTILATORS.

Each fire-room ventilator is to be so fitted that it can be easily closed from fire-room in case its blower is stopped.

Four ventilators, 18 inches diameter, are to be fitted—two to each engine-room; they will lead down the engine-room hatches, or as directed: their cowls will be worked from the engine-rooms. All ventilator-cowls will be made of copper No. 12 B. W. G., unplanished.

DUPLICATE PIECES.

Three extra blades will be furnished for each screw-propeller, to be of such dimensions as may be required.



# TESTS OF STEEL FOR CRUISERS.

## INSTRUCTIONS TO INSPECTORS.

The following rules are prescribed in order to insure the fulfillment of the clause of the Act of Congress of August 5, 1882: "Such vessels * * * to be constructed of steel of domestic manufacture, having as near as may be a tensile strength of not less than sixty thousand pounds to the square inch, and a ductility in eight inches of not less than twenty-five per centum."

I. All ship-plates, beams, angles, rivets, bolts, boiler-plates, and stays to be inspected and tested at the place of manufacture by a Naval Inspector of Material, and to be passed by him, subject to restrictions hereinafter mentioned, before acceptance by the ship-builders, whether Government or private, for incorporation into said vessels.

II. Every plate, beam, and angle supplied for these vessels to be clearly and indelibly stamped in two places, and with two separate brands: 1st. With that of the maker, which shall distinguish the name of the manufactory or company; 2d. With the regulation brand of the Naval Inspector of Material. The latter not to be stamped upon any of the above-mentioned material until it shall have passed an inspection for surface or other defects of manufacture and the physical tests have been accepted by the Inspector and have been stamped with the maker's brand.

In case of small articles passed in bulk the above-mentioned brands shall be applied to the boxing or packing material of the objects.

No steel material to be received at the building yards for incorporation into vessels except it bear, either upon its surface or that of its packing, both of these brands as evidence that it has passed the necessary Government inspection.

III. The weight of all plates, beams, angles, &c., must be obtained by the Inspector of Material before delivery.

Plates of 12½ lbs. per square foot or less, and strips and bars of 6 lbs. per lineal foot or less, may be accepted if the weights vary between 3 per cent. above and 5 per cent. below the specified weights.

All other plates and shapes may be accepted if the weights vary between the specified weights and 5 per cent. below them.

All plates and shapes not being within the limits here specified may be rejected.

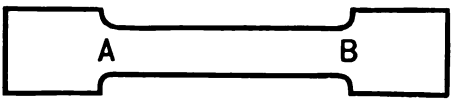
TESTS.

All material except boiler-plates should be tested by heats as follows:

A specimen ingot or bloom shall be selected and rolled into a plate or bar and test pieces cut therefrom, provided always that the test pieces shall have received no more working than that which the finished material from the heat would receive.

Four test pieces, of the form shown in Fig. 1, for plates, (square or round, in condition as finished at the rolls, may be used for the tests of shapes,) shall be made and tested for each heat.

*Fig.* 1.




The length A B must be at least 8 inches of uniform cross-section of which the area should not be less than $\frac{1}{4}$ nor more than $\frac{8}{10}$ of one square inch.

The reduction of width throughout the length A B should be just sufficient to prevent failure in the grips.

The test pieces must not be annealed unless the finished material is to be annealed.

Each test piece shall be submitted to a direct tensile stress until it breaks, in a machine of approved character.

The initial stress to be 30,000 pounds per square inch.

The first load to be kept in continuous action for one minute.

An observation to be made of the corresponding elongation measured upon the original length of 8 inches.

The stress then to be increased slowly until the principal elastic limit is determined, after which additional loads will be added at intervals of time nearly as possible equal, and separated by half a minute, the loads to produce an increase of stress of 5,000 pounds per square inch of original section of the test piece, until the stress is about 50,000 pounds per square inch of original section, when incre



ments of stress should not exceed 1,000 pounds per square inch. Upon close approach to the possible ultimate strength the load to be increased gradually and its maximum value carefully noted.

The final elongation to be that obtained after rupture.

A list of all ingots made from each heat must be supplied to the Inspector. Each ingot should be stamped in his presence with the number of the heat. He should also see the test plate or billet cut off, stamped, and rolled, and place a private stamp upon it in such a way that each test piece will have the impression of the stamp near one end.

CONDITIONS OF ACCEPTANCE.

In order to be accepted the average of the four test pieces must show an ultimate tensile strength of at least 60,000 pounds per square inch of original section, and a final elongation in 8 inches of not less than 25 per centum.

Material which shows a strength greater than 60,000 pounds per square inch will be accepted, provided the ductility remains at least 23 per centum.

CASES OF FAILURE.

If the average of these four test pieces, numbered 1, 2, 3, and 4, (called Test I,) fall below either of the required limits, the ingot from which pieces 1, 2, 3, and 4 were cut shall be rejected, and Test II made, consisting of pieces 5 and 6 cut from a second ingot; if the mean of the results of these two fall below either of the above limits the entire lot shall be rejected. If it be successful Test III, or the mean of pieces 7 and 8 cut from a third ingot, shall decide.

If in any of the Tests I, II, III, any single piece shows a tensile strength less than 58,000 pounds, or a final elongation less than 21 per cent., the ingot from which it was taken shall be rejected and that test considered to have failed, regardless of its average.

QUENCHING TEST.

IV. A test piece shall be cut from each plate, angle, or beam, and after heating to a cherry-red plunged in water at a temperature of 82° Fahrenheit. Thus prepared it must be possible to bend the pieces under a press or hammer, so that they shall be doubled round a curve of which the diameter is not more than one and a half times the thickness of the plates tested, without presenting any traces of cracking



These test pieces must not have their sheared sides rounded off, the only treatment permitted being taking off the sharpness of the edges with a fine file.

Inspectors may require a cold-bending test when considered necessary.

ANGLES, BEAMS, BULB-BARS, T-BARS, ETC.

V. Angle-bars are to be subjected to the following additional tests: A piece cut from one bar in twenty to be opened out flat, while cold, under the hammer; a piece cut from another bar in the same lot shall be closed until the two sides touch, while cold.

Bulb and T-bars are to be submitted to a closing test similar to that prescribed for angle-bars.

Bars submitted to these tests must show neither cracks, clifts, nor flaws.

RIVETS.

Each 1,000 lbs. of rivets from the same heat of metal shall constitute a lot; and be accompanied by two sample bars, each 18 inches long, for tensile test. These samples for tensile test shall be cut from the bars from which the lot of rivets is made, and be stamped with a number which shall also be placed on each box or package of that lot.

These samples to be subject to the same tensile test as that required for the plates.

The lot of rivets from which this sample bar does not fulfill the requirements of tensile strength and elongation required for plates, is to be rejected.

From each lot, six rivets are to be taken at random and submitted to the following tests, two rivets to be used for each test: 1st. Two rivets to be flattened out cold under the hammer to a thickness of one-half the diameter, without showing cracks or flaws. 2d. Two rivets to be flattened out hot under the hammer to a thickness one-third the diameter, without showing cracks or flaws. 3d. Two rivets to be bent cold into the form of a hook with parallel sides, without showing cracks or flaws.

BOILER MATERIAL.

Two tensile test pieces shall be cut from each plate rolled for boilers; and one quenching test piece, which shall be tested as before described, except that, in the tensile tests, the initial stress may be 25,000 lbs. to the square inch.



The limits of strength for all plates, braces, stays, angles, and T-bars, shall be as follows:

The ductility in eight inches must not be less than 25 per centum, and the ultimate tensile strength must not be less than 57,000 lbs. and not more than 63,000 lbs; and no single piece must show a less tensile strength than 57,000 lbs to the square inch, except plates for flanging and those used in the construction of the furnaces, which will have an ultimate tensile strength of not less than 50,000 and of not more than 55,000 lbs., and a ductility in eight inches of not less than 29 per cent.

No steel for boilers which is to be worked at a heat or to be annealed after working in the boiler-shops, shall be annealed at the works.

The acceptance of material under these tests will not relieve the contractor from the necessity of making good any material which fails in working or may be rejected by the Inspector.



# TEST OF HOLLOW STEEL-SHAFTS.

1. Each length of rough-forged shaft should have a piece cut from it, at that end which was uppermost in the ingot, of sufficient size to allow the removal of specimens for tensile test, parallel with the axis of the shaft, having a measured length of 4 inches between reference marks and of ¼ square inch sectional area when finished.

2. From the piece so removed, four test-pieces shall be taken, two at circumference of finished diameter and two at ¼ radius from centre. These pieces to be broken in a machine of approved character, under the same conditions as prescribed for "Tests of Steel for Cruisers."

3. The ultimate tensile strength of the four pieces must be within the limits of 26 and 30 tons (of 2240 lbs.) per square inch, and that of no single piece may fall below 25 tons. Pieces showing greater tensile strength than 30 tons will be accepted, provided the required ductility and other tests are satisfied.

The ductility of no piece at outer radius may be less than 20 per cent., and that of no piece of inner radius less than 16 per cent., in the measured length of 4 inches.

4. Bars ½-inch thick, cut at the outer radius, must stand bending double to an inner diameter of 1½ inches after common quenching in water, from a low cherry-red temperature.

5. Pieces cut from the rough-forged shaft for test, may not be sub jected to any subsequent treatment or process.

6. Inspectors of steel-shafting shall have full facilities to assure themselves of the general good quality of the metal and of a satisfactory method of manufacture, and may reject any piece considered to be defective in quality or fabrication, without regard to the prescribed tests.